Memo

Date:	December 16, 2019
To:	Dean Peschel
From:	Cristhian Mancilla Thomas W. Gallagher, Namita Joshua
Subject:	TN Concentration-Load Response Of Great Bay Estuary System

A total nitrogen (TN) concentration-load response (regression) was developed by HDR for the Great Bay Estuary System (GBES)[1]. This regression was developed for Great Bay proper, station GRBGB. The regression includes model-computed annual average TN concentrations at GRBGB and total annual TN loads to the GBES. Concentration data points for this regression represent model results of multiple TN reductions scenarios assessed in the original study for three modeling years (2010, 2011 and 2017); specifically, combinations of two point source (PS) load reduction scenarios (TN monthly limits of 8.0 mg/L and 3.0 mg/L) and four nonpoint source (NPS) load reduction scenarios (0%, 20%, 30% and 40%). There are ongoing efforts in New Hampshire to determine a GBES TN concentration that is protective of GBES eelgrass health. The TN concentration-load regression allows the computation of the corresponding GBES TN load for any selected target TN concentration for protection of eelgrass. This memorandum summarizes a comparison made between the model-computed concentration-load response and a similar regression derived from actual TN measurements.

The original study developed a TN concentration-load relationship for station GRBGB, a location that synthetizes the overall TN loads in the system but also represents a critical area for the evaluation of eelgrass in the GBES. However, TN concentration measurements at this station are very limited (7-10 measurements per year) to properly define an annual average concentration. Additionally, this station does not include measurements for both tidal conditions (high and low); only low tide measurements are performed at such location.

[1] HDR, Inc., 2019. "Development of Great Bay Estuary System Total Nitrogen Model", Mahwah, NJ.

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The Adams Point monitoring station (GBBAP), also a good location for assessing TN concentrations in general, includes twelve samples per year and each sample reflects an average of both low and high tide measurements. It was determined then to perform, similarly to the analysis performed for station GRBGB in the original study, a concentration-load regression using the model-computed concentration results at Adams Point and then compare such relationship to a regression obtained from actual TN data measurements at the same location. The model-based TN concentrations at Adams Point vs total TN load to the GBES is presented in Figure 1 (green squares). The corresponding regression (green line) and equation are also shown in such figure. The Adams Point equation is very similar to the GRBGB equation derived in the original study. The Adams Point equation reflects an intercept of 0.15 mg/L, indicating that, with no GBES PS or NPS TN loads, the oceanic TN boundary of 0.2 mg/L produces a TN of 0.15 mg/L at this location. The equation also indicates that every 100 kg/ha-yr of TN load produces a TN concentration increase of 0.1 mg/L at that location.

There is available TN concentration data for the Adams Point station for the years 2003 to 2017. However, years with at least twelve measurements per year are 2006-2011 and 2013-2017. During the implementation of the original modeling study, HDR developed daily NPS TN loads for each of the GBES tributaries by employing the LOADEST model; NPS loads were computed for the years 2008-2017. The original study had certain amount of WWTF effluent TN data for the years 2010, 2011 and 2017 as these were the study modeling years; such data was employed to compute either monthly or annual PS TN loads. For the present analysis, given that NPS loads are available for the 2008-2017 time period, PS TN loads were estimated for the same time period. These estimates were based on the original study PS loads analysis as there was no readily available effluent TN data for each year (2008-2017). Therefore, given the available annual NPS and PS loads and TN concentration data at Adams Point (with at least twelve measurements per year), years included in the data-based concentration-load regression were 2008-2011 and 2013-2017 (9 years). The data-based annual average TN concentrations and annual average loads to GBES are shown on Figure 1 (red triangles); the resulting regression (red line) and equation are also presented in such figure.

Both regressions produce a TN concentration increase of 0.1 mg/L at Adams Point for every 100 kg/ha-yr of TN load (0.001, the slope of the regression equations); however, the equation intercepts (constant in the equations) are slightly different. The model-based and data-based regressions are not expected to be exactly the same. Some possible reasons for the difference between the regressions could be: the twelve TN grab samples are rather limited to define an annual average (model-computed annual concentration averages are based on 365 daily values), lab measurement errors, resuspension events not represented by the model, etc. A significant issue is that, as mentioned in the original study report, a data-based concentration-load response for GBES is not “clean” enough when considering the uneven distribution of the current PS & NPS loads (both in magnitude and location). A simple way to visualize this concept is, for example, assessing Pierce Island WWTF effluent TN effects at Adams Point. Under current conditions Pierce WWTF is approximately 30% to 40% of the total PS TN load to the estuary and significant changes in such load would produce insignificant TN concentration changes at Adams Point as, on average, Pierce's percent effluent at that location is about 0.044[2]. The model-based regression is performed for multiple TN reduction scenarios where all PSs are at either a monthly permit of 8.0 mg/L or a monthly permit of 3.0 mg/L; these loads are relatively more comparable. A possible approach in reconciling both concentration-load regressions is to exclude the Pierce WWTF TN load from both regressions. For the model-based regression this load exclusion is relatively minor, while for the data-based regression such exclusion is more significant. Figure 2 presents the resulting regressions when excluding Pierce WWTF TN load from both datasets. There is quite an improvement in the level of agreement between both regressions. Based on this comparison of the model-based and data-based concentration-load responses at Adams Point, it can be concluded that the GBES nitrogen model and the TN reduction alternatives implemented with such model in the original modeling study are a good representation of the actual TN balance at the GBES.

[2] HDR, Inc., 2013. "Calibration of Great Bay Estuary Hydrodynamic Model and Incremental Nitrogen Estimation", Mahwah, NJ.

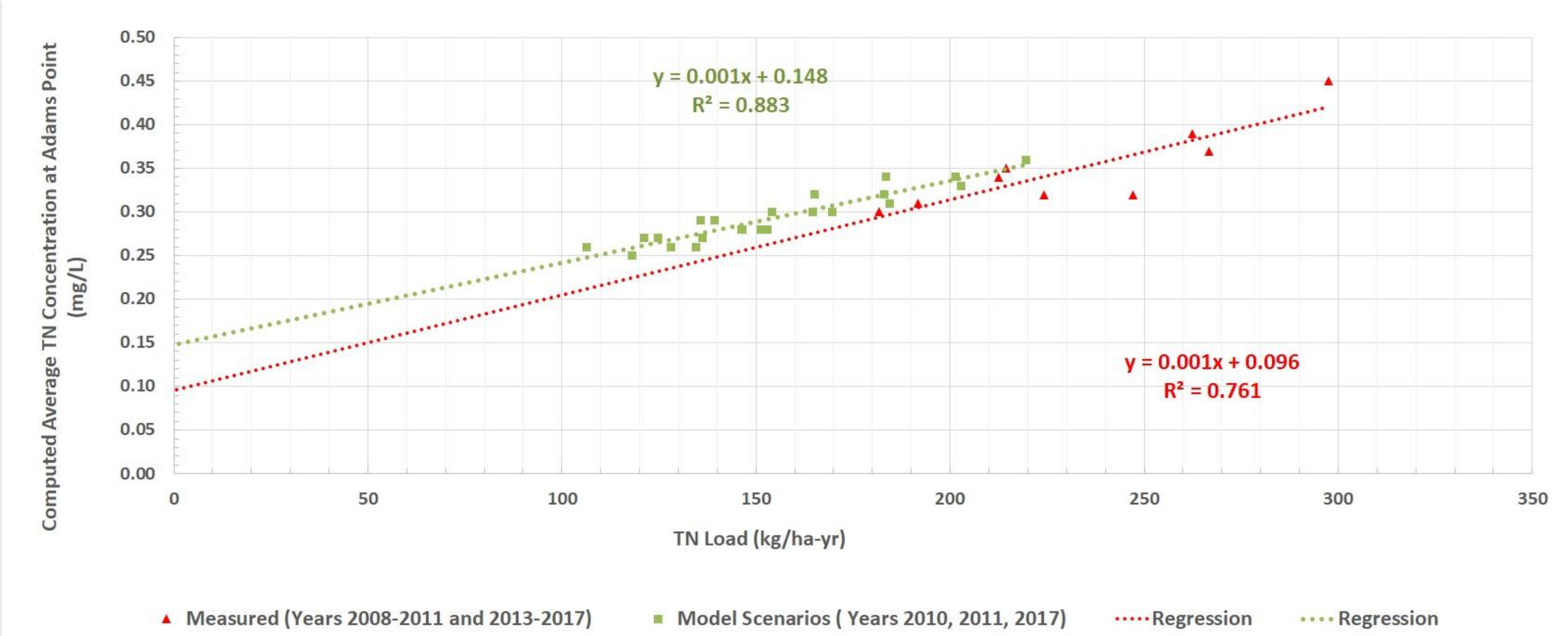

Figure 1. GBES TN Annual Load vs TN Concentration in Adams Point

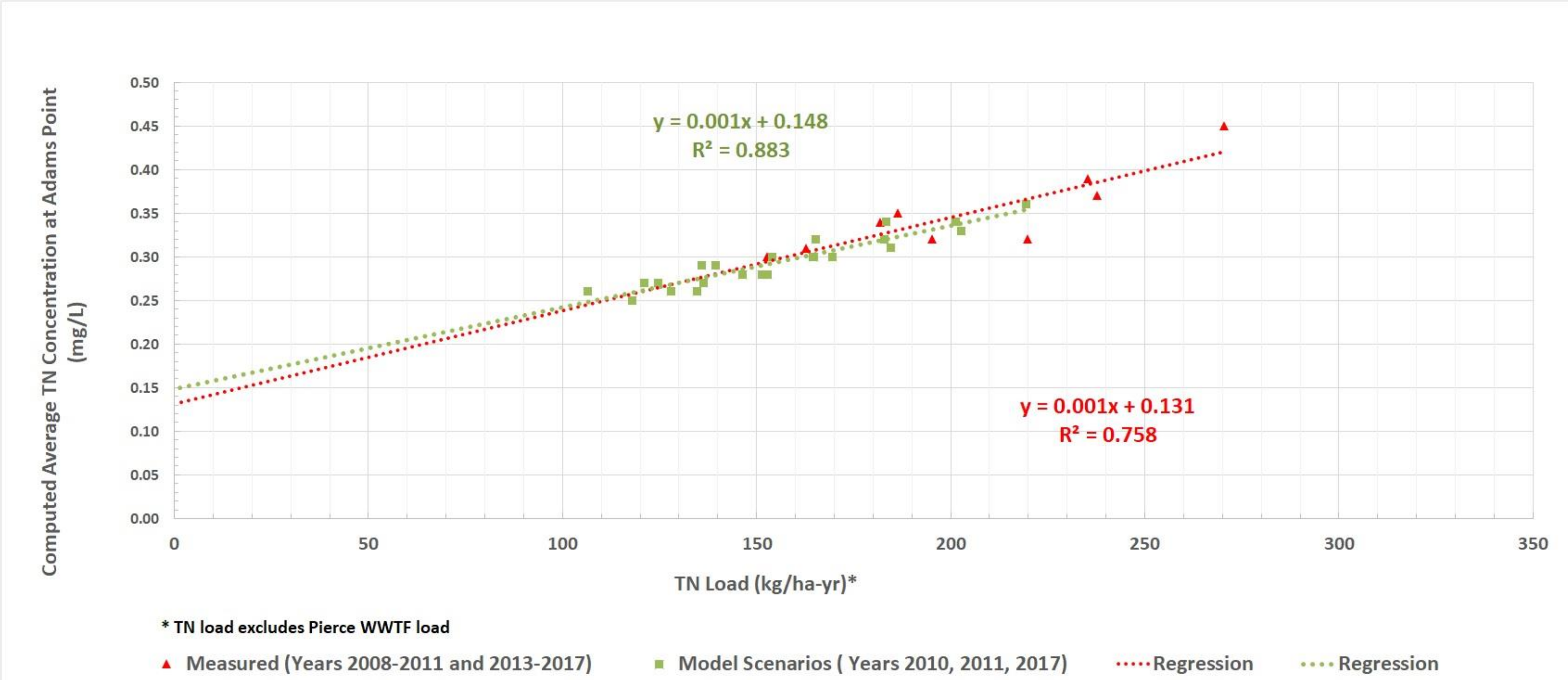

Figure 2. GBES TN Annual Load (excluding Pierce WWTF load) vs TN Concentration in Adams Point